Proposed Recommendations for a Pavement Distress Rating System And Score Calculation Procedures For Washington State Local Agencies

January, 2002

DRAFT

To: The NWPMA/WSDOT Committee on Pavement Index Score Review

From: Derald Christensen

Re: Proposed rating and index algorithm standard for local Washington State agencies

As discussed and agreed to in our last Committee meeting (January 8, 2001) I am providing the attached Proposed Pavement Distress Rating System for use by Local Agencies in Washington State. The intent of this document is two fold; first it is intended as a formal history of past and current rating practices in Washington State and how and why they are used. The second is to provide a starting point for the Committee to help in making a final recommendation. Encompassed in both of these objectives, is the fact that this document should also serve as a reference and as a learning tool to help each committee member to better understand our final goals. Therefore, some of the material provided in this document is provided for reference purposes only and is not intended for inclusion in any final document which may be derived from what is included here.

The recommended distress rating procedures and associated score calculation algorithms provided here have been developed over several years (starting in 1984) and through the input of many different Washington State local agency personnel. Because of this, it obviously reflects the needs and desires of these individuals and their associate agencies. MRC has taken these procedures and refined them through many thousands of miles of ratings and applications to various agency PMS needs and objectives. In this process these rating procedures have been applied to both large and small agencies, both city and county agencies and to many different repair and maintenance strategy needs and has included driving, walking and video/laser surveys. This system is in use by over 30 Washington State local agencies, all of whom do not want to change their current rating method. Some of these agencies have over 15 years experience with these procedures.

Please do not take any errors or inconsistencies in this document for any reason other than the author's lack of time to edit it as thoroughly as he would wish or that things may have been included for completeness and form, even if the true facts need further research. It is in part the object of the intended review process to help do the final editing and to make any needed changes, additions or deletions to this document.

Respectfully,

Derald Christensen

Local Agency Pavement Distress Index Algorithm

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Proposed Rating Index Algorithm/Procedure For Washington State Local Agencies

Introduction

This document is intended as a proposed standard, which can be used as a starting point for the NWPMA/WSDOT Rating Committee's consideration for a new rating score calculation procedure for use by Washington State Local City and County Agencies. The intent is for this procedure to augment the current NWPMA/WSDOT Pavement Surface Condition, Field Rating Manual, (currently in use by local agencies), by providing a flexible method for computing distress index values from the field rating data provide by the implementation of this document.

The basis for this proposed procedure was developed over the last 15 years through interaction between various Local Washington State Agencies and the WSDOT. It has been proven through many 1000's of miles of ratings by many different agencies. It's initial intent was to provide a detailed rating system which meets the specific needs of the local city and county agencies while still providing the data required to comply with the use of current and past WSDOT rating procedures and index score calculations.

This document starts out with a brief history of the various rating methods and related index score calculations, which have been (or are currently) in use within the State, by both the local city and county agencies and the WSDOT. One of these methods, which is currently in wide use, is then expanded on and is proposed as a starting point for the final recommendations which the above mentioned committee can work with and propose to the NWPMA/WSDOT as a final procedure which will be recommended for use by all local agencies.

Of key interest in the development of the procedures recommended here are the need to separate both structurally related and non-structurally related distresses to help better provide the information required for proper rehabilitation decisions as well as to address the level of detail required for using the results for routine and preventative maintenance operations. Also, careful attention has been given in the development of these procedures so as to provide data that can be used to comply with existing methods used by WSDOT and many of the counties. A final important aspect of the procedures being proposed here is the extreme level of flexibility in how they can be implemented.

Past experience has proven that, if the rating procedures and the related score calculations are not flexible enough and to some extent definable by the user, that each agency tends to make changes which better meets their specific needs and the tendency is for multiple systems to develop. This recommended procedure has been implemented in such a way as to allow an agency to make modifications while still providing a means of standardizing on at least one index that can be maintained as a common standard that will provide a means of comparison between agencies. To meet this goal a standard set of deduct curves needs to be developed and agreed on, while providing for a separate set of curves which the user can modify to meet specific goals.

The current NWPMA distress manual defines an "A" and "B" method, where the "A" method is intended for windshield type data collection and the "B" method is intended for more detailed distress surveys. The procedure proposed here and the way it is proposed to be implement provides for both of these methods. It also allows an agency to mix different aspects of each.

The final portion of this recommendation covers the proposed multiple indices and also contains a comparison of the index values produced by each of the methods discussed here along with the recommend use, advantages and limitations associated with each procedure.

History of Rating Methods in Use in Washington State

Introduction

The WSDOT was one of the first agencies to develop and implement a pavement distress rating system. They started developing their rating system and what they call a priority array in the 1960's. The Washington State Legislature initially mandated the development of this procedure. This initial rating system included 4 distresses and a windshield method for collecting the data based on the predominant distress severity and % wheel path extent measurements.

There are four different rating systems currently in use in Washington State by the State and the Local Agencies. All of which have been developed and/or condoned by the WSDOT and a fifth method (WSEXT/OCI) which was developed by the local Washington agencies themselves through their NWPMS User's Group, which was later reorganized into the current NWPMA organization. Also, there are two different WSDOT approved rating manuals and the original manual developed by the NWPMS group, which is the pavement distress description portion of the CenterLine PMS Raters Manual. The text from this manual is included in Appendix E.

The following is a list of these different rating methods:

1. Original WSDOT Mat1rix Base Windshield Rating method (PCR_1)
2. WSDOT Matrix Method modified for Local Agencies (PCR_2)
3. WSDOT Pavement Structural Condition Index (PSC_1) – continuous extents

3b. WSDOT Pavement Structural Condition Index (PSC_2) – discrete extent ranges

4. Streetwise Rating System (PCR_3)
5. WSDOT Local Agency Method Using ASTM Curves – Washington State Extended Method (WSEXT) or the modified ASTM/PAVER method.

1. Original WSDOT Matrix Base Windshield Rating Method (PCR1)

This method uses four distress types, longitudinal cracking, alligator cracking, maintenance patching and transverse cracks. Its basic premise is that it is a structural index, meant only to monitor load related fatigue (alligator) cracking. By definition, longitudinal cracking is the beginning stage of alligator cracking (low severity level), the alligator cracking distress type is define as the intermediate or medium severity level and patching the advanced or high severity alligator cracking (it has gotten so bad as to require patching). The transverse cracks are included to help model the needs of eastern Washington pavements, which are subjected to frost heave and related distress problems. To use this index correctly, the data must be collected as indicated by the above descriptions. Defining patching as the advanced stage of fatigue cracking and assigning high deduct values to it was done in part to insure the continued deterioration (shape) of the performance curve model used by the WSDOT.

2. WSDOT Matrix Method adapted for Local Agencies (PCR_2)

In 1984 the WSDOT contracted with the University of Washington to develop a PMS for local agencies based on their current system. The above rating system (PCR_1) didn't meet the local agencies needs in several ways and thus was modified to correct these insufficiencies.

First other distress types were added and the deduct values modified in the deduct matrices. These new distress types included raveling, flushing, rutting, sags & humps and corrugations. Also, the definitions for longitudinal cracking and patching were modified to better meet the local agency needs.

3. WSDOT Pavement Structural Condition Index (PSC)

In 1993 the WSDOT and the University of Washington published the documentation for a new method of computing the index score for the States distress rating method. No changes were made to the way the different distresses were rated, other than allowing for continuous extent measurements. This system uses a series of equations which were fit to existing data and developed around the idea of reducing each distress to its equivalent level of alligator cracking, a method similar in concept to the pavement design procedure which is based on equivalent thickness. This approach has some validity in the context of the above description of how the WSDOT rates their pavements, in that all they are actually monitoring is alligator (or fatgue) cracking. However, this method and this approach to computing the index does not apply to local agencies except possibly for high volume urban arterial pavements in the larger counties. But even to this day none of the counties rate their roads in complete compliance with the WSDOT procedures, even though most use the PSC index. The current WSDOT raters' manual does not even conform to the rating procedures required by the PSC and its initial development. This makes this index invalid and its use questionable by these local agencies. This index is not used by any of the local city agencies in Washington State or is it used outside of this state.

The initial correlation work done by the DOT on these data with the PCR_1 data showed reasonable results, however, the DOT does not let their pavements go below a score of 50. This is not true for local agencies and the differences are reflected in the comparison shown in later in this document. This difference is quit severe for the higher extent of alligator cracking for all severity levels.

4. Streetwise System Distress Index (PCR_3)

This method uses five distresses, alligator, longitudinal and transverse cracking, patching and raveling. That is, it adds raveling to the original WSDOT method. However, it differs in how the index value is computed. A series of index score based matrices are used and only two distresses are included; alligator cracking and the predominate one of the other distresses, if present. The purpose of this approach was to provide a simplified paper and pencil method for the smaller local agencies. From the comparisons shown later in this document, it is clear that no correlation work was done with any of the existing rating systems in developing the Streetwise matrix values. The future use of this index will most likely be replaced by the index resulting from the work of the current index evaluation committee.

5. WSDOT Method Using ASTM/PAVER Curves (WSEXT) or the modified PAVER method

The original WSDOT matrix based system and the PSC if windshield data collection procedures are used, have a shortcoming, in that they were based on quantifying the extent using ranges or groupings and the predominate severity to help simplify their use for collecting data from a moving vehicle. This causes large variations from year-to-year in the results, and makes it extremely difficult to obtain

consistent results from different raters. It also does not provide the data needed to manage maintenance operations. For these reasons (and others) the local agencies decided to go to a detailed quantification of each extent for each distress severity level by collecting and recording actual areas and lengths for each distress type and severity level. This method requires the use of continuous deduct curves in place of matrices. This method was developed from the PCR_2 procedure by the local agencies themselves and was adopted in the late 1980's. It is currently used by most local agencies involved in PMS in Washington State and is the primary method provided for in this proposed standard.

Unfortunately, the WSDOT has never formally adopt deduct matrices or curves for the procedures adopted by the local agency or by the research project which developed their PMS. Therefore, the individual agencies and software developers have adopted their own which has resulted in a large array of individual distress score index systems. Since most Cities have adopted the WSEXT or OCI index method outlined in this document this has not been an extremely difficult problem for them. However, for the counties that wish to use distress data such as rating rutting, raveling, flushing and others, they have been forced to adopt two indices, the PSC which is required by CRAB/WSDOT and the OCI, which provides the better index for making PMS, related MR&R decisions. This can cause extreme difficulty in trying to share or communicate this type of data between various departments and/or individuals within an agency and to controlling bodies such as the CRAB and the WSDOT. Also, as can be seen in Appendix D, this can greatly effect the proper or optimized development of your MR&R lists.

A comparison of these indices is included in this document. It can be seen that in the case of the PSC (WSDOT equations) and the PCR_3 (Streetwise) there is an extreme difference in the deduct values assigned in many cases. For a single agency, using a single index score, this may or may not make any difference as long as the accompanying MR&R decision process matches the rating system/method and the desires of the user. However, make sure that your rating system can provide the trigger values and distress types you need to make the decisions required by your MR&R operations. It should also be noted that different indexes can provide extremely different MR&R repair lists and care should be given to this fact when making decision as to how you rate your pavements and as to how you compute the related indices.

Some unique examples, which relate to this topic include:

1. San Juan County, which has only rural chip seal roads. They previously used the PSC to manage their system. Sense most of their distress was flushing; they were not including their primary distress information in the score (PSC) values they were using to manage their pavements. Because CRIS included raveling and flushing on their data entry screen they assumed it was used in the calculation of the PSC and were unaware of the fact that it wasn't.
2. Arterial and Collector streets must be managed separately by most city agencies. Because of this a strictly structural based index may work for the arterial and collector arterial streets but would not be adequate for residential streets.
3. Most counties have separate urban and rural roadway networks, each of which requires different distress data to be manage properly. Only an index that includes structural and non-structural distress data can meet the combined needs of such a network.
4. Only a state route system that does not include local access or residential pavements can be managed from a structural index only.
5. Also, careful examination of the results in Appendix D applies.

Further Discussion

The original WSDOT windshield rating procedures only include four distress types, Longitudinal Cracking, Alligator/Fatigue Cracking, Maintenance Patching and Transverse Cracking. Longitudinal Cracking is defined as the initial stage of load related Alligator Cracking. Alligator cracking is defined as fully developed Alligator Cracking and Patching as the advanced stage of Alligator Cracking (the repair of). Therefore, only two distress types are being monitoring, Alligator cracking and Transverse Cracking. For this reason the WSPSC & $WSPCR_1$ rating procedure and resulting computed scores represents a pavement structural index and are currently being called the PSC (Pavement Structural Condition Index). WSDOT originally called this the PCR or "Pavement Condition Index". Full details of how this system is implemented are included later in this document.

This rating system is well suited for properly engineered pavements, which fail due to their designed repetitive truck loadings. However, it does not address or account for any other mechanism of pavement failure or provide an indicator of a pavements need for rehabilitation or maintenance due to distresses other then alligator cracking. This can be a limitation for local agencies and should be well understood when implementing and using these systems. The WSEXT rating system is designed for and intended as a natural expansion of these systems and provides full compatibility while providing for other needs, which are more indicative of local agency requirements. A comparable structural index can still be computed while allowing for other indices to be evaluated, such as environmentally (non-structural) related distresses which includes raveling, as well as rutting, ride and roughness/profile.

The PCR and PSC systems were intended to be used for statewide comparison purposes and must be implemented as outlined here to accomplish this. Therefore, a clear understanding of how these systems are used by WSDOT is important for local agencies to understand. The four distresses used in computing the PSC (and PCR_1) and the way in which the data is collected must be included in any system used by local agencies if these indices are to be computed or used. This will allow continued use of these systems and will allow continued use of previously collected data, while still providing for comparisons between agencies.

To address the need to compute different indexes from the same data set and to try to provide continuity or comparable score results from one method to another, the WSEXT method has include several features. First, care was taken in defining the individual distresses and how the data is to be collected, so as to allow for the ability to meet the needs and requirements of each of the different rating and score calculation method. This is most apparent in the separation of longitudinal cracking into separate structural and non-structural distresses. The structural longitudinal cracks are than compatible with the PSC requirements while still allowing for the collection of data for the non-structural longitudinal cracks. Also, sense utility repairs make up a large proportion of a local agencies patches, the separation of this distress type into utility and maintenance patching allows for compatibility with how the PSC handles patching, while also providing data that is more useable by the local agencies. This separation also helps address the many current issues associate with the better management of utility patches. These types of considerations allow both the CDI and PSC indices to be computed from the same data set if care is taken to following the proper distress definition and quantification procedures during your data collection.

The WSEXT system being proposed here also provides user defined units of measure for each distress type, which can be changed from one survey year to the next. Examples of this would be the ability to switch from percent length or wheel path extent measurements to the quantification of the actual distress area measurements. Also, this proposed unit of measure conversion capability includes the ability to switch from discreet extent ranges (Method A) to detailed extent measures (Method B in the current NWPMA/WSDOT raters manual) within the same piece of software. This capability was originally developed to help local agencies to migrate from the original WSDOT $PCR_{1\&2}$ rating methods, to the

WSEXT method and has been used and proven over the last 15 years. The proposed WSEXT method includes both the Method A and Method B definitions provided for in the current WSDOT raters manual in one system or process.

If other changes should result from further development of this new standard, care needs to be taken to insure that previously collected data and previous procedures for computing indices is compatible and can be used in the development of fitted performance curves which are based on past and current distress scores/indices. Not adhering to this, along with any other possible changes to the existing system (WSEXT) that do not meet an individual agencies needs, will only result in them altering their procedures. That is, the more one tries to constrict and force an agency to comply with a standard that does meet their needs the higher the probability that an agency will be forced to modify how they implement their rating system and the more fragmented things become. This is evident in the fact that there are 6 different rating systems currently in use by local Washington State Agencies. Also, some of the larger agencies have modified there rating systems, in some cases quite extensively, to meet their individual needs. This means that there are actually a lot more then the 6 rating systems discussed here currently in use within the State. Only a properly designed and agreed to standard will result a uniform rating system statewide. See the WSDOT report WA-RD 274.1.

Distress Rating Procedures

Both the PCR_1 & PSC rating procedures include four distress types, Longitudinal Cracking, Alligator/Fatigue Cracking, Patching and Transverse Cracking. Therefore, both the PSC and PCR_1 represent a structural index and do not reflect any pavement deterioration related to environmental or other non-structural defects in the pavement. In operating your PMS this becomes especially import in that no MR&R type decisions or related planning or budgeting can be performed aside from the overlaying or reconstruction of structurally failed roadways.

If the discrete finite range method of implementing the WSPSC approach is being used, both the WSPSC and WSPCR systems use identical rating procedures and extent ranges but have quite different score values. That is, the only difference is in how the resulting score is computed for each system. If actual % area and % length extent data are being collected, only the WSPSC system applies and defines a separate rating system from the use of the discrete extent ranges with the WSPSC procedures. Therefore, there is two ways in which the WSPSC rating procedures can be implemented. When using the discrete ranges of extent, a mid-point range value is assumed and used in place of the actual extent in solving the equations used in this system.

$WSPCR_1$ - Washington State Discrete Pavement Condition Rating System

Introduction

This system is based on the pavement distresses and rating procedures outlined in the original raters manual provided by WSDOT, and to some extent in the Method A of the current WSDOT local agency distress raters manual and is summarized here. It includes alligator, longitudinal and transverse cracking and patching and was used by the WSDOT for many years, until the early 1990's when they switched to the PSC method which is outlined later in this document.

Objective

This system was developed with the goal of optimizing its use for collecting the distress data from a moving vehicle. It is a structural pavement distress index, in that it only reflects structural type distresses caused by heavy repeated traffic loadings and the repair and maintenance of these distresses.

Method

The extents associated with all three severity levels of each distress are grouped (summed) together into the most predominate severity and the extents are defined using finite ranges of extent and percent wheel path to define the quantity. This allows the rater to quickly make decisions and to quantify the data as they drive the roadway. This method is also used by some agencies for walking surveys. The data being collected can be put directly onto a form or this system can be easily adapted to an automated type keyboard based system connected directly to a distance-measuring instrument (DMI).

Each combination of severity and extent range is assigned a value (which is called a deduct value). These deduct values are provided in a matrix format and are given below. The proper deduct value is selected for each existing distress type by going to the appropriate matrix and locating the proper extent range and severity row and column and selecting the deduct number locate at the point where they meet. These deduct values for each existing distress within a given segment of pavement are then summed together and subtracted from 100 to compute the PCR score.

This score can go below zero and may be truncated or tapered below a given value within your PMS software to account for potential analysis problems associated with these negative values. The ASTM rating system defines a tapering or smoothing process, which is applied when multiple distress types or severities of a given distress occur within the same segment, which will automatically remove the possibility of negative indices. This is the preferred method even with the $WSPCR_{1\&2}$ procedures and should be an available option within your PMS software and included with this proposed standard. WDOT has traditionally called this index the Pavement Condition Rating or PCR.

$$PCR = 100 - \sum_i Deducts_i$$

Recommended Use

This method is used quite extensively in Washington State and is ideal for low budget applications and network level budget planning. This method can be easily expanded, by changing to an actual area and length method of measuring the extent and the recording of data for each severity level.

Figure 1 - Extent Ranges Used for each Distress Type

Extent Ranges	Alligator Cracking	Longitudinal Cracking	Transverse Cracking	Patching
1	0 - 9%	1% - 99%	1 - 4 Cracks	1% - 9%
2	10% - 24%	99% - 199%	5 - 9 Cracks	10% - 24%
3	25% - 49%	200% or more	10 or more	25% or more
4	50% or more	-	-	-

Figure 2 - Asphalt and Bituminous Pavement Deduct Matrix

Extent	Alligator Cracks			Longitudinal Cracks			Transverse Cracks			Patching		
Range	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
1	20	35	50	5	15	30	5	10	15	20	25	30
2	25	40	55	15	30	45	10	15	20	25	30	35
3	30	45	60	30	45	60	15	20	25	30	40	50
4	35	50	65	-	-	-	-	-	-	-	-	-

Figure 3 - Composite Pavement Deduct Matrix

Extent	Alligator Cracks			Longitudinal Cracks			Transverse Cracks			Patching		
Range	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
1	20	35	50	5	15	30	5	10	15	20	25	30
2	25	40	55	15	30	45	10	15	20	25	30	35
3	30	45	60	30	45	60	15	20	25	30	40	50
4	35	50	65	-	-	-	-	-	-	-	-	-

Figure 4 - Portland Cement Concrete Pavement Deduct Matrix

Extent	Faulting			Cracking			Joint Spalling		
Range	Low	Med	High	Low	Med	High	Low	Med	High
1	5	10	15	5	10	15	5	10	15
2	10	20	30	10	20	30	10	20	35
3	20	30	40	20	35	50	15	30	50

FLEXIBLE PAVEMENT DISTRESSES – WINDSHIELD

1. Fatigue (Alligator) Cracking
   - Severity: 1 = Low — Discontinuous branched & thin longitudinal cracks
     2 = Medium — Fully developed alligator pattern with some spalling
     3 = High — Severe spalling and pumping
   - Extent: Percentage of the length of both wheel paths.
     1 = 1% - 9% of both wheel paths
     2 = 10%-24% of both wheel paths
     3 = 25%- 29% of both wheel paths
     4 = 50%-or more of both wheel paths
2. Longitudinal Fatigue Cracking
   - Severity: 1 = Low — Less than ¼ inch
     2 = Medium — Greater than ¼ inch with Spalling
     3 = High — Greater than ¼ inch with Spalling and Pumping
   - Extent: Percentage of the length of the surveyed segment
     1 = 1% -99% of the length of the segment
     2 = 100% - 199% of the length of the segment
     3 = 200% or more of the length of the segment
3. Tansverse Cracking
   - Severity: Same as #2
   - Extent: Frequency, counts per 100 feet.
     1 = 1-4 cracks per 100 ft.
     2 = 5-9 cracks per 100 ft.
     3 = 10 or more cracks per 100 ft.
4. Patching – Maintenance
   - Severity: 1 = Low — Chip seal patch.
     2 = Medium — Blade patch.
     3 = High — Dig-out, Full depth patch.
   - Extent: Percentage of length of both wheel paths.
     1 = 1% - 9% of both wheel paths
     2 = 10% - 24% of both wheel paths
     3 = 25% or more of both wheel paths

WSPCR2 – Local Agency Windshield Distress Rating System

Introduction

The original $WSPCR_1$ windshield rating procedure was expanded for local agency use to include additional distress types. This rating procedure has been referred to as the "Local" deduct method in earlier Washington State PMS literature. The following Figures show the deduct matrices currently used by the CenterLine software for this system. These raveling and flushing deducts are also used with the current detailed walking distress survey (WSEXT). Even though this procedure was developed for local agencies by WSDOT research funds, WSDOT has never establish or set standards for the use of this system. The numbers given below are being proposed as a standard and were taken from the ASTM curves using the mid-point extent for each extent range.

Objective

This system was developed from the $WSPCR_1$ method with the goal of optimizing its use for local agencies. It was also the first step in the development of a final rating system, which is the WSEXT or Washington State Expanded rating system. This system (the WSEXT) is outlined later in this document and is the method being proposed for final acceptance for use by the Washington Local Agencies.

Method

The extents associated with all three levels of each distress are grouped (summed) together into the most predominate severity and the extents are defined using finite ranges of extent and percent wheel path to define the quantity. This allows the rater to quickly make decisions and to quantify the data as they drive done the roadway. This method is also used by some agencies for walking surveys. The data being collected can be put directly onto a form or this system can be easily adapted to an automated type keyboard based system connected directly to a distance-measuring instrument (DMI).

Each combination of severity and extent range is assigned a value (which is called a deduct value). These deduct values are provided in a matrix format and are given below. The proper deduct value is selected for each existing distress type by going to the appropriate matrix and locating the proper extent range and severity row and column and selecting the deduct number locate at the point where they meet. These deduct values for each existing distress within a given segment of pavement are then summed together and subtracted from 100 to compute the PCR score.

This score can go below zero and may be truncated or tapered below a given value within your PMS software to account for potential analysis problems. The ASTM rating system defines a tapering or smoothing process, which is applied when multiple distress types or severities of a given distress occur within the same segment, which will automatically remove the possibility of negative indices. This is the preferred method even with the $WSPCR_{1\&2}$ procedures and should be an available option within your PMS software. WDOT has traditionally called this index the Pavement Condition Rating or PCR.

$$PCR = 100 - \sum_i (DeductsValues)_i$$

Recommended Use

This method is used quite extensively in Washington State and is ideal for low budget applications and network level budget planning. This method can be easily expanded, by changing to an actual area and length method of measuring the extent and the recording of data for each severity level. The WSEXT method was developed from this method.

Figure 5a - Extent Ranges Used for each Distress Type

Extent Ranges	Corrugation	Raveling/ Flushing	Block Cracking	Edge Conditions	Rutting
1	0 - %	1% - 99%	> 9'x9'	1-9%	¼" – ½"
2	10% - 24%	99% - 199%	5'x5'- 9'x9'	10-24%	½" – ¾"
3	25% - 49%	200% or more	4'x4' or less	> 25%	> ¾"
4	50% or more	-	-	-	-

Figure 5b - Suggested Flexible Pavement Deducts – Taken from ASTM Deduct Curves

Extent	Alligator Cracks			Longitudinal AC Cracks			Transverse Cracks			Maintenance Patching		
Range	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
1	24	38	52	11	22	45	11	22	45	5	22	37
2	39	56	69	16	31	62	16	31	62	20	41	68
3	44	59	74	29	44	86	29	44	86	50	58	80
4	56	74	87	-	-	-	-	-	-	-	-	-

Extent	Corrugation			Raveling/Flushing			Block Cracking			Edge Conditions		
Range	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
1	15	43	64	5	20	45	10	18	33	5	11	20
2	26	56	80	10	30	65	18	32	55	11	22	40
3	36	70	86	15	40	75	25	40	70	20	40	80

Extent	Rutting			Crack Sealing?		
Range	Low	Med	High	Low	Med	High
1	25	45	60	1-9%	10-25	> 25

Portland Cement Concrete Pavements (PCC)

For the PCC streets the rater is to count each slab containing a given severity level of a given distress. The density is the percent slabs or the number of slabs with a given distress divided by the total number of slabs. The extent ranges are the same for all distress types except for wear, which is the same as for rutting in flexible pavements. These extent ranges are

Figure 6a - Extent Ranges Used for each PCC Distress Type

Extent Ranges	Wear	All other Distresses
1	¼" to ½"	1% to 9% slabs
2	½" to ¾"	10% to 24% slabs
3	over ¾"	> 25% of slabs

Figure 6b - Suggested Portland Cement Concrete Pavement Deducts – from ASTM Curves

Extent	Raveling			Pumping			Faulting		
Range	Low	Med	High	Low	Med	High	Low	Med	High
1	6	18	35	10	20	35	5	15	30
2	10	25	48	20	35	45	20	30	50
3	15	30	60	35	45	55	30	50	75

Extent	Cracking			Joint Cracking			Patching		
Range	Low	Med	High	Low	Med	High	Low	Med	High
1	20	35	52	5	10	25	5	10	30
2	35	50	70	10	15	35	15	30	45
3	48	70	85	15	25	50	25	45	65

Extent	Wear			Blowups		
Range	Low	Med	High	Low	Med	High
3	10	20	30	35	70	90

Severity and Extent Summary for $WSPCR_2$ Surveys

The following is a summary of each pavement distress type and its quantification in terms of severity (how bad the distress is) and extent (over what area/length does it exist). The extent ranges given below are intended for use in a moving windshield survey. Entry a 1, 2 or 3 into the appropriate severity column on the form for each distress type observed. All severity levels are included in the predominate severity when estimating extent quantities. Rate only the outer lane in one direction is common. Percent length or actual areas & lengths can also be used for measuring the extent.

FLEXIBLE PAVEMENT DISTRESSES

1 Rutting and Wear

Severity: The average rut depth in the wheel path for the segment or sample.

1 = Low ¼ in. to ½ in.
2 = Medium ½ in. to ¾ in.
3 = High over ¾ in.

Extent: Assumed to be the full length/area of the surveyed segment.

2 Fatigue (Alligator) Cracking

Severity: 1 = Low Longitudinal cracks.
2 = Medium Fully developed alligator pattern with some spalling
3 = High Severe spalling and pumping

Extent: Percentage of the length of both wheel paths.

1 = 1% - 9% of both wheel paths or by area
2 = 10%-24% of both wheel paths or by area
3 = 25%- 29% of both wheel paths or by area
4 = 50%-or more of both wheel paths or by area

3. Longitudinal Fatigue Cracking - Rate as low severity Fatigue cracking
4. Longitudinal Reflective Cracks

Severity: 1 = Low Less than ¼ inch
2 = Medium Greater than ¼ inch with Spalling
3 = High Greater than ¼ inch with Spalling and Pumping

Extent: Percentage of the length of the surveyed segment or by length
1 = 1% -99% of the length of the segment or by length
2 = 100% - 199% of the length of the segment or by length
3 = 200% or more of the length of the segment or by length

5. Transverse Cracking

Severity: Same as #3

Extent: Frequency, counts per 100 feet.
1 = 1-4 cracks per 100 ft. or by length
2 = 5-9 cracks per 100 ft. or by length
3 = 10 or more cracks per 100 ft. or by length

6. Raveling and
7. Flushing Rated in same column on form – Place a "F" in the raveling/Flushing flag for flushing and "R" for raveling.

Severity: 1 = Low Slight
2 = Medium Moderate
3 = High Severe

Extent: 1 = Localized
2 = Wheel Paths
3 = Entire Lane

8. Patching – Maintenance
9. Patching – Utility

Severity: 1 = Low Good condition.
2 = Medium Moderately deteriorated – ride medium.
3 = High Badly deteriorated – ride poor.

Extent: Percentage of length of both wheel paths.
1 = 1% - 9% of both wheel paths or by area
2 = 10% - 24% of both wheel paths or by area
3 = 25% or more of both wheel paths or by area

Comments: Utility patching is rated separately

10. Corrugation and Waves

Severity: The maximum deviation from a 10-foot straight edge
1 = Low 1/8-in. to 2-in. change per 10 ft.
2 = Medium 2-in. to 4-in. change per 10 ft.
3 = High Over 4-in. change per 10 ft.

Extent: Same as #9

11. Sags and Humps

Severity: Same as #10

Extent: Same as #9

12. Block Cracking

Severity: Block Size
1 = Low 12-ft. x 12-ft. blocks (9x9 and larger)
2 = Medium 6-ft. x 6-ft. blocks (5x5 to 8x8)
3 = High 3-ft. x 3-ft. blocks (2 x 2 to 4 x 4)

Extent: Assumed to be the full length of the segment.

13. Pavement Edge Condition

Severity: 1 = Low Edge patching extent (severity is undefined)
2 = Medium Edge raveling extent (severity is undefined)
3 = High Edge lane less than 10 feet extent (severity is undefined)

Extent: Percent of twice the segment length.

14. Crack Seal Condition

Severity: 1 = Low Hairline cracks in the sealant allow only minimal water passage.
2 = Medium The crack sealant is open and will allow significant water passage.
3 = High The crack sealant is very open or non-existent.
Extent: Same percentages as #9 but based on the total length of all cracks &/or joints.

RIGID PAVEMENT DISTRESSES – $WSPCR_2$

1. Cracking
   Severity: Low 1 crack per lane panel.
   Medium 2 or 3 cracks per panel.
   High 4 or more cracks per panel.
   Extent: 1 = 1% to 9% of the slabs are cracked.
   2 = 10% to 24% of the slabs are cracked.
   3 = 25% or more or the slabs are cracked.
2. Joint and Crack Spalling
   Severity: Low 1/8-in. to 1-in. spalls.
   Medium 1-in. to 3-in. spalls.
   High Greater than 3-in. spalls.
   Extent: Same as #1.
3. Pumping and Blowing
   Severity: Low Slight shoulder/lane depression, no staining.
   Medium Significant depression, slight staining.
   High Severe depression, significant staining.
   Extent: Same as #1.
4. Faulting and Settlement
   Severity: Low 1/8-in. to ¼-in. faulting or settlement at joints or cracks.
   Medium ¼-in. to ½-in. faulting or settlement at joints or cracks.
   High Over ½-in. faulting or settlement at joints or cracks.
   Extent: Same as #1.
5. Patching
   Severity: Low Patch is in good condition.
   Medium Patch show low to medium distress and ride quality.
   High Patch shows severe distress and poor ride quality.
   Extent: Same as #1.
6. Raveling or Scaling
   Severity: Low Aggregate or binder has started to wear.
   Medium Aggregate and/or binder has worn away & the surface texture is moderately rough.
   High Aggregate and/or binder have worn away significantly.
   Extent: Same as #1.
7. Blowups:
   Severity: Not defined.
   Extent: Number of occurrences per segment.
8. Wear
   Low ¼ to ½ inch.
   Medium ½ to ¾ inch.
   High over ¾ inch.
   Extent: The extent or wear is assumed to be the full length of the segment.

WSPSC - Washington State Pavement Structural Condition Index Equation Based System

Introduction

This rating system uses the same distress types and descriptions as the $WSPCR_1$ system and was developed as a replacement for this procedure. It uses a series of regression equations developed from field data and is in part based on an attempt at trying to define longitudinal and transverse cracking and patching in terms of equivalent alligator cracking. As stated by its developer, this is not a vary robust or rigorous mathematically defendable procedure, however, it meets their needs.

Objective

To expand the original PCR_1 procedure to include the use of a continuous method of collecting distress data while providing a smooth path from the PCR_1 method. It also excludes any possibility of including other distresses and thus has been renamed as the "Pavement Structural Condition" index.

Method

This system uses a series of equations to compute the resulting score, which is called the Pavement Structural Condition Index (PSC). This system can be used with the above discrete matrix based procedure (the PCR_1) by assigning fixed mid-point extent values for each extent range. The actual percentages associated with the extent for each distress type and severity can also be used with these equations. This actually defines two separate rating methods. The following is a section of computer code used to represent these equations. See the WSDOT publication WA-RD 274.1 for full details on how these equations were developed and documentation on this and the PCR_1 procedures. The objective here is to give the user a quick overview of how the PSC is calculated

Recommended Use

This procedure is intended for monitoring pavements which only experience failure do to structural loadings and is only applicable to a State Highway system. It is not recommended for use by local agencies.

Alligator Cracking

EqAC = AL_HGH+(0.445*AL_MED**1.15)+(0.13*AL_LOW**1.35)þ

Patching

EqPT = PT_HGH+(0.445*(PT_MED * 0.75)**1.15)+(0.13*(PT_LOW * 0.75)**1.35)

Longitudinal Cracking

EqLC = (0.1*LC_HGH)+(0.445 *(LC_MED*0.1)**1.15)+(0.13*(LC_LOW*0.1)**1.35)

Transverse Cracking

EqTC = (0.6*TC_HGH)+(0.445 *(TC_MED*0.6)**1.15)+(0.13*(TC_LOW*0.6)**1.35)

EqC = EqAC + EqPT +qLC + EqTC

SegDed = 15.8 * EqC**0.5

IF SegDed > 100 THEN SegDed = 100

PCR = 100 - SegDed

SegDed = Segment Deduct value

* - Symbol for multiplication

** - Symbol for raising a number to a power

Where: (All distress data are entered in % of Wheel Path/length, or count for transverse cracking, the mid-point of the extent range is used for $WSPCR_1$ method)

Alligator Cracking			WSPCR Mid-Point Extent
AL_HGH	=	gh severity	37.5%
AL_MED	=	dium Severity	12.5%
AL_LOW	=	Severity]	4.5%
Patching			
PT_HGH	=	gh severity	75%
PT_MED	=	dium Severity	12.5%
PT_LOW	=	w Severity	4.5%
Longitudinal Cracking			
LC_HGH	=	High severity	50%
LC_MED	=	Medium Severity	100%
LC_LOW	=	Low Severity	150%
Transverse Cracking			
TC_HIGH	=	High severity	2 Cracks
TC_MED	=-	Medium Severity	50
TC_LOW	=	Low Severity	150

FLEXIBLE PAVEMENT DISTRESSES

1 Fatigue (Alligator) Cracking

Severity: 1 = Low — Discontinuous branched & thin longitudinal cracks
2 = Medium — Fully developed alligator pattern with some spalling
3 = High — Severe spalling and pumping

Extent: Percentage of the length of both wheel paths.
1 = 1% - 9% of both wheel paths
2 = 10%-24% of both wheel paths
3 = 25%- 29% of both wheel paths
4 = 50%-or more of both wheel paths

2 Longitudinal Fatigue Cracking

Severity: 1 = Low — Less than ¼ inch
2 = Medium — Greater than ¼ inch with Spalling
3 = High — Greater than ¼ inch with Spalling and Pumping

Extent: Percentage of the length of the surveyed segment
1 = 1% -99% of the length of the segment
2 = 100% - 199% of the length of the segment
3 = 200% or more of the length of the segment

3 Transverse Cracking

Severity: Same as #2

Extent: Frequency, counts per 100 feet.
1 = 1-4 cracks per 100 ft.
2 = 5-9 cracks per 100 ft.
3 = 10 or more cracks per 100 ft.

4 Patching – Maintenance

Severity: 1 = Low — Chip seal patch.
2 = Medium — Blade patch.
3 = High — Dig-out, Full depth patch.

Extent: Percentage of length of both wheel paths.
1 = 1% - 9% of both wheel paths
2 = 10% - 24% of both wheel paths
3 = 25% or more of both wheel paths

$WSPCR_3$ - StreetWise Pavement Rating System

Introduction

WSDOT Highways and Local Programs division developed this system for use by smaller agencies, originally under a population of 2500. Rehabilitation funds are associated with the use of this system and the WSDOT plans to expand it's use to Cities of 5000 population and eventually even larger Cities.

Objective

The primary objective of this system was to provide smaller local agencies with a simplified rating method that could be applied using paper and pencil methods.

Method

This system uses alligator cracking plus one of four possible secondary distresses to define its pavement score index. It uses a series of score based matrices to compute the score and quantifies the distresses in a similar manner as in the PCR_1 procedure. See the WSDOT StreetWise Manual for full details. This manual states that the current NWPMA/WSDOT Raters manual is to be used for the distress survey, however, it should be noted that it uses a mixture of the method A & method B definitions for how the extents are quantified. Specifically, raveling and patching are measured by actual area of distress and not as a percentage of the wheel path.

It sums all extent values together to compute the density and assigns this value to the predominate severity level, the same as in previous WSDOT procedures. It also uses the same 5 (instead of 3, 4 for alligator cracking) extent levels for all distress types. The procedures for computing the distress density for each distress type are shown below.

Extent ranges for all distresses:

1 = 0% - 1%
2 = 1% - 5%
3 = 5% - 10%
3 = 10% - 25%
4 = 25%-or more

FLEXIBLE PAVEMENT DISTRESSES

1. Fatigue (Alligator) Cracking

Severity:	1 = Low	Discontinuous branched & thin longitudinal cracks
	2 = Medium	Fully developed alligator pattern with some spalling
	3 = High	Severe spalling and pumping
Extent:	Measure wheel path length containing distress	
Density :	(Length of wheel path with distress / twice the segment length) x 100	

2. Longitudinal Fatigue Cracking - Rate as low severity Fatigue cracking

Severity: 1 = Low Less than ¼ inch
2 = Medium Greater than ¼ inch with Spalling
3 = High Greater than ¼ inch with Spalling and Pumping

Extent: Measure wheel path length containing distress

Density : (Length of wheel path with distress / the segment length) x 100

3. Transverse Cracking

Severity: Same as #2

Extent: Frequency, counts per 100 feet.
1 = 1-4 cracks per 100 ft.
2 = 5-9 cracks per 100 ft.
3 = 10 or more cracks per 100 ft.

Density : (Number of cracks per 100 feet / the segment length) x 100

4. Raveling

Severity: 1 = Low Slight
2 = Medium Moderate
3 = High Severe

Extent: Area of ravel for each severity level

Density : (Area of distress / the segment area) x 100

5. Patching – Maintenance

Severity: 1 = Low Chip seal patch.
2 = Medium Blade patch.
3 = High Dig-out, Full depth patch.

Extent: Area of ravel for each severity level

Density : (Area of distress / the segment area) x 100

Recommended Use

This system is only recommended for use by smaller agencies. The WSDOT is currently in the process of computerizing this system and placing it on the Internet. At that time they also plan to consider the possibility of changing to the distress rating procedures recommended by this committee.

WSEXT – Washington State Extended Method or Modified ASTM/PAVER System

(This method is being proposed as a Standard for Local Agencies)

Introduction

To better meet the needs of local agencies and to make better use of automated rating procedures and to address the needs of managing routine and preventative maintenance operations, an extension to the original WSDOT WSPCR/WSPSC procedures has been developed and successfully implemented over the past 16 years. This rating procedure is referred to as the extended WSDOT rating system (WSEXT) and is a natural expansion of the original $WSPCR_{1\&2}$ methods and provides the ability to measure the extent of the various distress types in greater detail and thus allow for the use of continuous deduct curves. It also provides access to several additional distress types not available in the PCR_1 and PSC methods. This system currently uses the ASTM system and associated deduct curves with minor changes and was developed by the local agencies themselves. However, modifications to these curves are being recommended and are outlined in Appendix A. The above changes to the ASTM/PAVER rating procedures include the following:

These items/changes in the ASTM system are included in the current NWPMA/WSDOT Raters manual and need to be documented and maintained as is:

1. Transverse and longitudinal non-fatigue cracking is rated as two separate distresses
2. A separate longitudinal fatigue crack distress type is included
3. Rutting extent is assumed to be the full segment area and only the average depth is recorded.
4. Edge raveling has been expanded to include edge patching & edge lane width less than 10 feet. The current implementation defines edge patching as low level PAVER edge raveling, edge raveling as medium and lane < 10' as high
5. Raveling and Flushing are rated using the predominate severity matrix method. This is actually an option if the conversion factor portion of this proposal is included.
6. Crack seal inventory/rating is included
7. Several of the ASTM/PAVER flexible distress types have not been included. These are distress type numbers 6, 8, 9, 12, 13, 14, 16, 17, 18. These are the numbers ASTM has assigned to each distress (See Figure 7).

The following is a list of additional variations from the current ASTM/PAVER procedures which need to be included and added to the current NWPMA/WSDOT Pavement Raters Manual in the form of an addendum along with the above seven items. The primary reason for item #2 below is to address the use of the rating data to drive an agency's routine maintenance operations, primarily crack sealing and patching. The response to this method of rating patching is often stated as patching is being rated twice. This can best be accounted for in the deduct curves. However, without this modification it is impossible to properly manage maintenance operations or model the cost estimates for maintenance.

8. Utility patching is included as a separate distress
9. Rate all distresses as if patching doesn't exist & then rate the condition of the patch separately
10. 100% sampling is recommended in all cases & not the 10%-to-100% sampling option as specified by ASTM standard. Single lane sampling will be allowed.

Where needed use the current CenterLine Distress Rating Manual (See Appendix E) as a guide for defining any needed definitions, etc. This manual contains the original descriptions developed by the Local Agencies. Consideration should also be given to/for allowing all deduct curves and related units of

extent to be adjustable/modifiable by the user, while establishing a standard set of deduct curves, which could be used for statewide comparisons. This is similar to the separate "State" and "Local" deduct matrices used in the original Local Agency PMS. At a minimum, adjust the deduct curves for the distress types marked in Figure 7.

Consideration should also be given to adding the following items as an addendum to the current rating manual or any future changes to the current raters manual.

- Consider changing the wording for Alligator cracking to read "Alligator (Fatigue) Cracking"
- Replacing "Longitudinal Cracking" with "Longitudinal Fatigue Cracking"
- Replacing "Longitudinal non-wheel path Cracking" with "Longitudinal Non-Fatigue Cracking".
- Change raveling & flushing in BST pavements. It should be rated as such and not reversed.
- Consider adding ride, profile/roughness and some measure/index for drainage.
- The use of both sample unit and full area sampling must be allowed for in the implementation of this procedure.
- The ability to change extent units of measure from one year to the next.
- This recommended rating procedure should be published as an actual WSDOT report, in the same way as the StreetWise rating procedure or PaveSmart System (M 36-64), and not just as an endorsement through the NWPMA as with the past raters manuals. This is the only way the problems associated with the last 15 years can be avoided in the future and that we can be assured that this issue will not be revised in the future. This will also establish this as an official endorsement by the WSDOT.

This system was developed over a 16-year period of application, starting in 1985, by local agencies within the northwest through joint research at the University of Washington, local agency user groups and the WSDOT. It reflects the needs and requirements of these agencies while still allowing for full compatibility with WSDOT's current rating operations. This system is currently being used by most of the larger Cities and Counties within the State and was developed out of an attempt by state and local agencies to establish a statewide standard uniform rating system.

Objective

To provide the detail and flexibility in a rating system that would allow its use by all local agencies.

Method - Distress Rating Procedures

The detailed distress rating description and procedures associated with the WSEXT method are provided in the CenterLine PMS Raters Manual (which is included as part of this recommendation in Appendix E) and are summarized in the following outline. In general these agree with the NWPMA manual, they actually both came from the same origin at one time. This system combines the $WSPCR_{1\&2}$ (WSDOT windshield rating system) and the ASTM systems and makes the best use of each. It is designed to provide for the varying needs of both large and small local agencies and is adaptable to automated rating systems. The primary difference between the original $WSPCR_{1\&2}$ systems and the WSEXT system is that several distress types have been added and the method of measuring the extent has been redefined to allow for detailed measurement of individual severities for each distress type. This also allows for the use of continuous deduct curves in place of the matrices now in use in the $WSPCR_{1\&2}$ calculations.

Also the distress quantification method used for raveling and flushing has not changed from the original $WSPCR_2$ procedures as originally defined for local agency use by WSDOT. The descriptions for Fatgue (Alligator) Cracking, Longitudinal Cracking and Maintenance Patching have been modified to allow for local agency needs while still providing compatibility with the WSPSC system.

The following section outlines the distress types and the way in which they are quantified and recorded. Please see the NWPMA and Appendices A through E for more details.

Severity and Extent Summary for WSEXT Surveys for flexible pavements

The following is a summary of each pavement distress type and its quantification in terms of severity (how bad the distress is) and extent (over what area/length does it exist).

FLEXIBLE PAVEMENT DISTRESSES

1. Rutting and Wear
   - Severity: Average Rut Depth over the segment.
   - Extent: Assume full segment length.
   - Data Entry: Single entry in 0.25 inch increments to right of description.
   - Comments: Estimate mean rut depth in inches. Use sags and humps for localized rutting.
2. Fatigue (Alligator) Cracking
   - Severity: (Crack size and Pattern)
     - Low — Branching inner connecting longitudinal cracks.
     - Medium — Fully developed alligator pattern with some spalling
     - High — Severe spalling and pumping
   - Extent: Entry the area of each severity in sq. units.
3. Longitudinal Cracking - Fatigue (Structurally) Related
   - Severity:
     - Low — Less than ¼ inch crack wide
     - Medium — Greater than ¼ inch crack wide.
     - High — Greater than ¼ in. Spalled cracks.
   - Extent: Enter the length in feet – enter separately for each severity
   - Comments: Fatigue caused longitudinal cracks are the early or first stage of distress #2. These cracks have a distinct broken pattern and occur in the wheel path.
4. Longitudinal Cracking - Non-Structural - Joint Reflective and Construction Joint - Same as #3
   - Comments: This distress tends to be straighter and has more distinct cracks than longitudinal fatigue/alligator cracks
5. Transverse Cracking - Same as #3
   - Comments: Include localized alligator cracking in the transverse direction as high transverse cracks.
6. Raveling
   - Severity:
     - Low — Binder &/or aggregate has started to wear away.
     - Medium — Binder &/or aggregate has worn away and is rough.
     - High — Surface texture is deeply pitted.
   - Extent:
     - Localized — 1 – Isolated patches of raveling.
     - Wheel paths — 2 – Both wheel paths are fully raveled.
     - Entire lane — 3 – Complete surface is raveled.
   - Data Entry: Enter predominate extent & severity to right of description – ex 2M=wheel path medium severity.
7. Flushing or Bleeding
   - Severity:
     - Low — Minor amount of aggregate is covered
     - Medium — Significant amount of aggregate is covered
     - High — Most of the aggregate is covered
   - Extent: Enter the area of distress in square feet
   - Comments: Rate raveling and flushing separately.
8. Patching – Maintenance
   - Severity:
     - Low — Good condition.
     - Medium — Moderately deteriorated – ride medium.
     - High — Badly deteriorated – ride poor.
   - Extent: Entry the area in square feet for each severity.
   - Comments: Utility patching is rated separately.
9. Patching – Utility: Rated the same as #8, maintenance patching
10. Corrugations and Waves

Severity: Low 1/8 in. to 2 in. change per 10 feet.
Medium 2 in. to 4 in. change per 10 feet.
High Over 4 in. change per 10 feet.

Extent: Enter the area in square units for each severity.

11. Sags and Humps - Same as #10
12. Block Cracking
    Severity: Low 9x9 foot and larger blocks.
    Medium 5x5 to 9x9 foot blocks.
    High Greatet then 9x9 foot blocks.
    Extent: Enter the area in sq. feet for each severity.
13. Edge Condition
    Severity: Low = Edge Patching
    Medium = Edge Raveling
    High = Lane less than 10 feet
    Extent: Enter the accumulated lengths for each severity.
    Comment: Rate both sides of the street.
14. Crack Seal Condition
    Severity: Low Crack sealant is in good condition.
    Medium Crack sealant is open and allows water into crack.
    High Crack sealant is missing or non-existent.
    Extent: Percent of total cracks that are sealed. Enter percentage for each severity.
    Comments: Example: 50L, 25M = 50% are sealed & in low condition plus 25% in medium condition. 25% are not sealed.
15. Ride Quality
    This is generally not collected with a walking survey, however, if desired assign a number from one to ten with one being a perfect ride and 10 being the worst. If automated equipment is used, enter the mean IRI (International Roughness Index) value. You may also want to record the maximum, minimum and standard deviation values.
16. Drainage Index
    This is generally not collected, however, if desired assign a number from one to ten with one being a good drainage score and 10 being the worst.

Note: Distresses 1, 6, 7, 14, 15 and 16 are entered on the center portion of the form to the right of the distress name itself. All of the other distresses are entered into the lower portion of the form by placing the number associated with the distress being measured at the top of the column and accumulating the various amounts of the distress in the cells below. The final amount (extent) of each distress is then totaled at the bottom of the form. There is also a place at the bottom of the form for the previous years rating data, which is included if available.

Severity and Extent Summary for WSEXT Surveys for rigid pavements

(This is the WSDOT method, the ASTM/PAVER system may be considered)

The following is a summary of each pavement distress type and its quantification in terms of severity (how bad the distress is) and extent (over what area/length does it exist). In distresses 1 through 6 extent is defined as the number of slabs containing a given distress while #7 is and individual count/event and #8 is an average depth.

1. Cracking
   Severity: Low 1 crack per panel
   Medium 3 cracks per panel
   High 4 or more cracks per panel
   Extent: Enter the number of slabs for each severity (Same for distresses 1 througth 6)
2. Joint and Crack Spalling

Severity: Low 1/8-in. to 1-in. spalls
Medium 1-in. to 3-in. spalls
High Greater than 3-in. spalls

3. Pumping and Blowing
   Severity: Low Slight shoulder depression, no staining
   Medium Significant depression, slight staining
   High Severe depression, significant staining
4. Faulting and Settlement
   Severity: Low 1/8-in. to ¼-in. faulting or settlement at joints or cracks.
   Medium ¼-in. to ½-in. faulting or settlement at joints or cracks.
   High Over ½-in. faulting or settlement at joints or cracks.
5. Patching
   Severity: Low Good condition.
   Medium Moderately deteriorated – ride medium.
   High Badly deteriorated – ride poor.
3. Raveling or Scaling
   Severity:
   Slight Aggregate and binder has started to wear away.
   Moderate Aggregate and/or binder has worn away & surface texture is moderately rough
   Severe Aggregate and/or binder have worn away significantly.
4. Blowups
   Severity: Not defined
   Extent: Number of occurrences per segment
5. Wear
   Severity: Enter mean depth to nearest ¼"
   Extent: The extent of wear is assumed to be the full length of the segment.

Recommended Use

This system is recommended for use by all agencies large and small. It is especially applicable for the development of detailed and accurate rehabilitation and reconstruction project lists as well as for managing preventative and routine maintenance operations. It helps add to the use of your PMS as a project tool as well as for network planning.

Distress Rating Computations/Procedures

The ASTM deduct curves are currently used with the WSEXT procedure for computing the resulting score. Figure 7 shows the ASTM curves used by the WSEXT system. Other "Deduct Curves" could be developed or these could be modified. The ability to do this, along with proper guidelines on how to do this should be included in your PMS software and in this proposed standard.

Figures $8_{a\&b}$ shows the conversion factors which are currently available in the CenterLine software and which are provided so as to allow for variations between different users and most importantly to provide a mechanism for allowing a given agency to change the way in which they measure the extent of any given distress from on year to the next. This feature is included in the recommendation for a final rating system. Another important advantage of this feature is that it allows methods A & B, which are in the current NWPMA/WSDOT Raters Manual, to be combined into a single rating score index algorithm. Therefore, this feature along with the ability to modify the deduct curves would give the end user the ultimate flexibility in using the proposed standard to meet any current or future needs or changes in their rating procedures. This is the single most important aspect of any new statewide rating standard, in that if it can't meet an agency's current or future needs they will most likely modify the system on their own or fail to make effective use of it.

Figure 7a - WSEXT - DEDUCT CURVE SUMMARY – Flexible Pavements

WSEXT		ASTM	
#	Distress Type	#	Curve Used
1	Rutting *	15	$WSPCR_2$ Matrix
2	Fatigue Cracking	1	Alligator Cracking
3	Longitudinal-Fatigue Cracks *	1	Alligator Low for all severities
4	Longitudinal-Reflective Cracks	10	Transverse & Longitudinal
5	Transverse Cracking	10	Transverse & Longitudinal
6	Raveling	19	WSDOT Deduct matrix - $WSPCR_2$
7	Flushing	2	WSDOT Deduct matrix - $WSPCR_2$
8	Patching -Maintenance	11	Patch & Utility Cuts
9	Patching – Utility *	11	Patch & Utility Cuts
10	Corrugations & Waves	5	Corrugation
11	Sags & Humps	4	Bumps and Sags
12	Block Cracking	3	Block Cracking
13a	Edge Raveling	7	Edge Cracking Medium
13b	Edge Patching	7	Edge Cracking Low
13c	Edge Lane < 10’	7	Edge Cracking High
14	Crack Seal Condition	-	Inventory only
15	Ride Index	-	N/A
16	Drainage Index	-	N/A

* These distress types need new or modified deduct curves or deduct values

Figure 7b - WSEXT - DEDUCT CURVE SUMMARY – Rigid Pavements

WSEXT		ASTM	
#	Distress Type	#	Curve Used
1	Cracking *	24	Durability “D” Cracking
2	Joint & Crack Spalling	39	Spalling
3	Pumping & Blowing	33	Pumping
4	Faulting and Settlement	25	Faulting
5	Patching	29	Patching, Large & Utility Cuts
6	Raveling or Scaling	36	Scaling/Map Cracking/Crazing
7	Blowups	21	Blow-Up, bucking/Shattering
8	Wear		

Note: The ASTM system could be used for PCC in place of the WSDOT.

Figure 8a Setup screen for defining rating distress quantification/conversion units

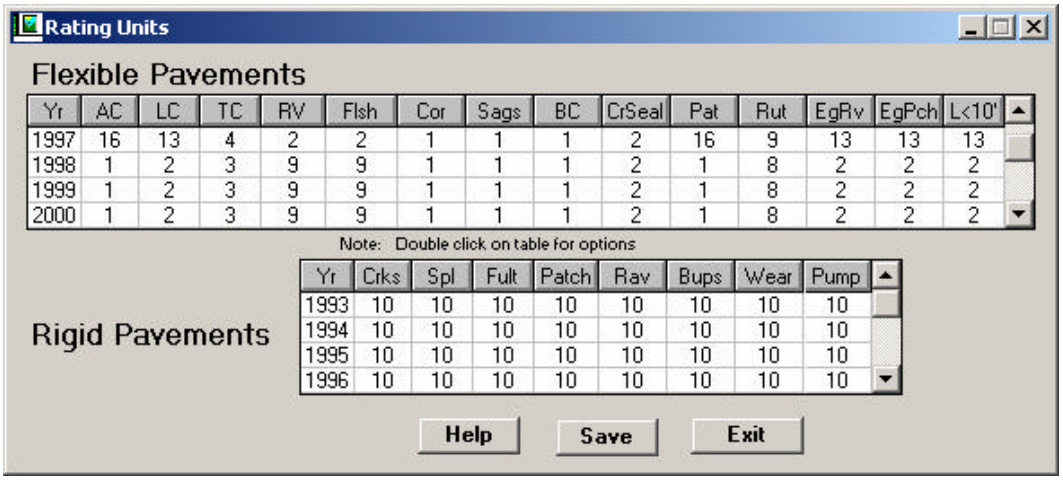
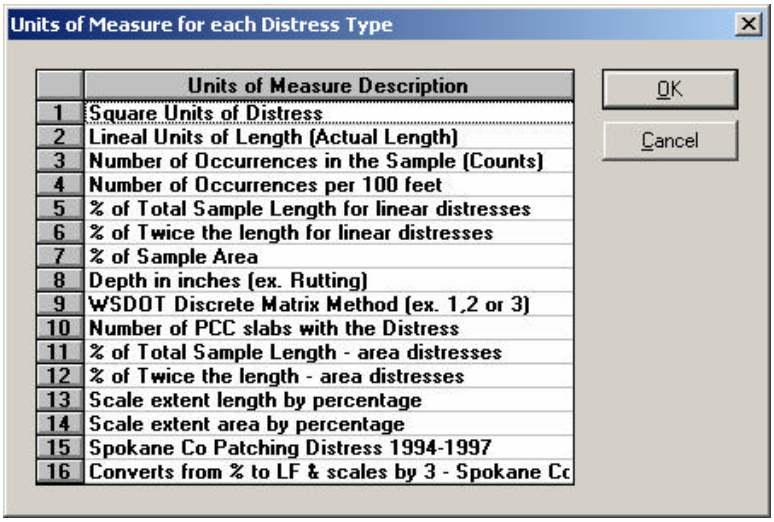


Figure 8b Available extent unit quantification options



Density equations for each unit of Extent option

The following is the actual equations associated with each of the unit density conversion options given in Figure 8b. Some of these are only applicable to a given agency and changes they've made in their past rating methods, such as numbers 13 through 16. These density conversion options can be applied independently to each survey year. Thus an agency can change the way they collect their rating data from one year to the next. This not only allows the moving from say a windshield type survey to a walking survey but it allows for more subtle changes such as changing from a wheel path extent measure to actual area or from one lane to the total segment area or manual to automated. This allows for the continuity in your data following such changes and thus provides for the use of this past data in the development of your default/family curves as well as for the development of your individual project performance curves. This option also allows the Methods A & B in the current NWPMA/WSDOT Raters Manual to be combined into on distress score algorithm or procedure. This system also allows for the use of both sample unit type data collection as well as the full segment area. The minimum recommended sample unit is one lane the full length of the segment. Therefore, the "Area" in the equations is the sample unit area (for full area sampling this would be the full segment area). In options 14 & 15 the "Su_" references the sample unit measures.

1.	Square Units of Distress	density = distress / Area
2.	Linear Units of Lengths	density = distress / Area
3.	Number of Occurrences in sample	density = (distress*(0.75*Su_Width)) / Area
4.	Number of occurrences per 100 feet	density = (distress*(Length/100)*(0.75*Su_Width))/Area
5.	Percent of sample length for linear	density = ((distress/100)*Length) / Area
6.	Percent of twice the length for linear	density = ((distress/200)*Length) / Area
7.	Percent of sample area	density = distress
8.	Depth in inches	density = (distress/3) / Area (3 inch rut = max deduct)
9.	Discrete matrix method	Uses matrices
10.	Number of PCC slabs	density = (distress/total slabs) / Area
11.	Percent of total sample length (area)	density = (((distress/100)*Length)*(Width/2)) / Area
12.	Percent of twice the length, area only	density = (((distress/200)*Length)*(Width/2)) / Area
13.	Scale extent length by percentage –	density = ((distress/100)*Length) / Area)
14.	Scale extent area by percentage –	density = ((distress/100)*Su_Area) / Area
15.	Spokane County Patching 1994-1997	density = ((distress*(2*Su_Width / Width)) / Area
16.	Convert % of linear feet & scale by 3	density = (((distress*(Length*2))/100)*3) / Area
17.	"3A" Longitudinal fatigue cracks	density = ((distress/4) / Area), if %, use density= distress

Final percent density = density*100

Detailed steps in performing the WSEXT index calculations

See Figure 9 for a graphic display of the steps required in computing the final index score. This is actually an extremely simple process once the deduct curves and the related correction process is defined. The following is a summary of the steps in Figure 9.

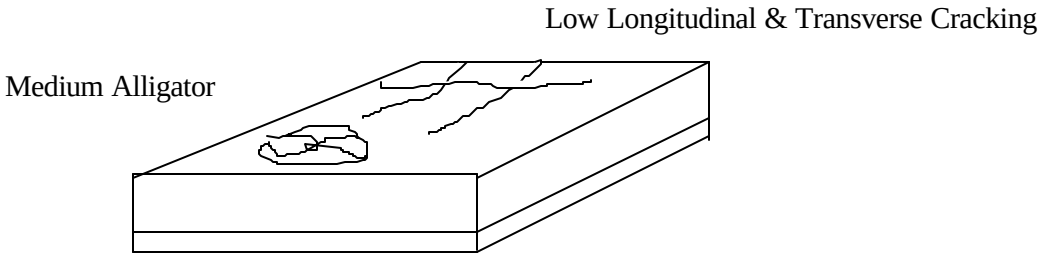
1. Compute proper density for each distress data item. See Figure 8.
2. Obtained the deduct values for each severity level of each distress. See Figures 7, A4 & A5.
3. Correct the deduct value using the ASTM Q-Curve correction algorithm (See Appendix B)
4. Compute the final score by subtracting the final corrected deduct value from 100

Summary and Recommendations

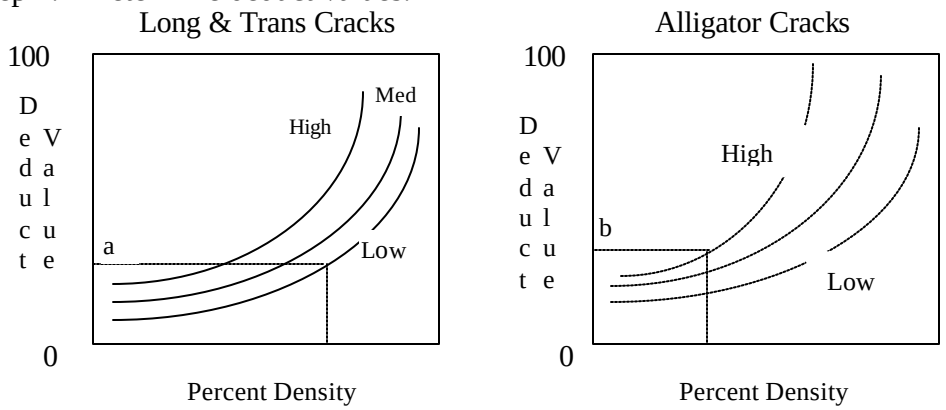
This system has been successfully implemented by most of the Cities within the State, which currently have operating PMS systems and by four counties. This procedure tends to provide different scores then the $WSPCR_{1 or 2}$ methods, due primarily to the fact that there are more distress types included in the WSEXT method. This fact could be addressed by adjusting the deduct values in the $WSPCR_{1 or 2}$ or by modifying the deduct curves in the WSEXT method if desired. Also, the use of discrete extent ranges tends to decrease the scores, apparently do to the tendency to place marginal extent quantities into the next here range and do to the fact that a large percentage of street segments tend to have 1 or 2% of a given distress severity and these get lumped with higher distressed pavements because of the size of the initial or first extent category. Therefore, care should be taken when making the transition if an agency is currently using WSPCR ratings procedures. This is also true for the WSPSC method. This will also affect your historical distress data and the resulting performance curves if you do switch from one system to the other.

The greatest advantage of the WSEXT method is the increased accuracy and detail in the data. This helps to provide more consistent data from survey-to-survey and allows for the better management and modeling of routine and preventative maintenance and other repair operations, such as your preparation costs associated with an overlay or seal coat. It also provides for a better selection/prioritization of rehabilitation projects. See Appendix D for more details.

Step 1 - Inspect sample units: Determine distress types and severity levels and measure density.

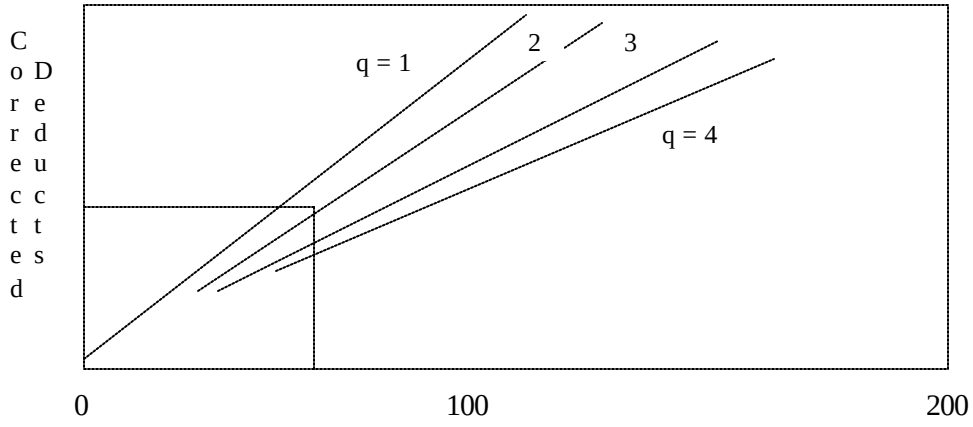


Step 2. - Determine deduct values.



Step 3. Compute total deduct value (TDV) = a+b

Step 4. Adjust total deduct value.



Step 5. Compute pavement condition index PCI/CDI = 100 - CDV for each for each inspected

Figure 9 – ASTM/WSEXT rating procedure diagram

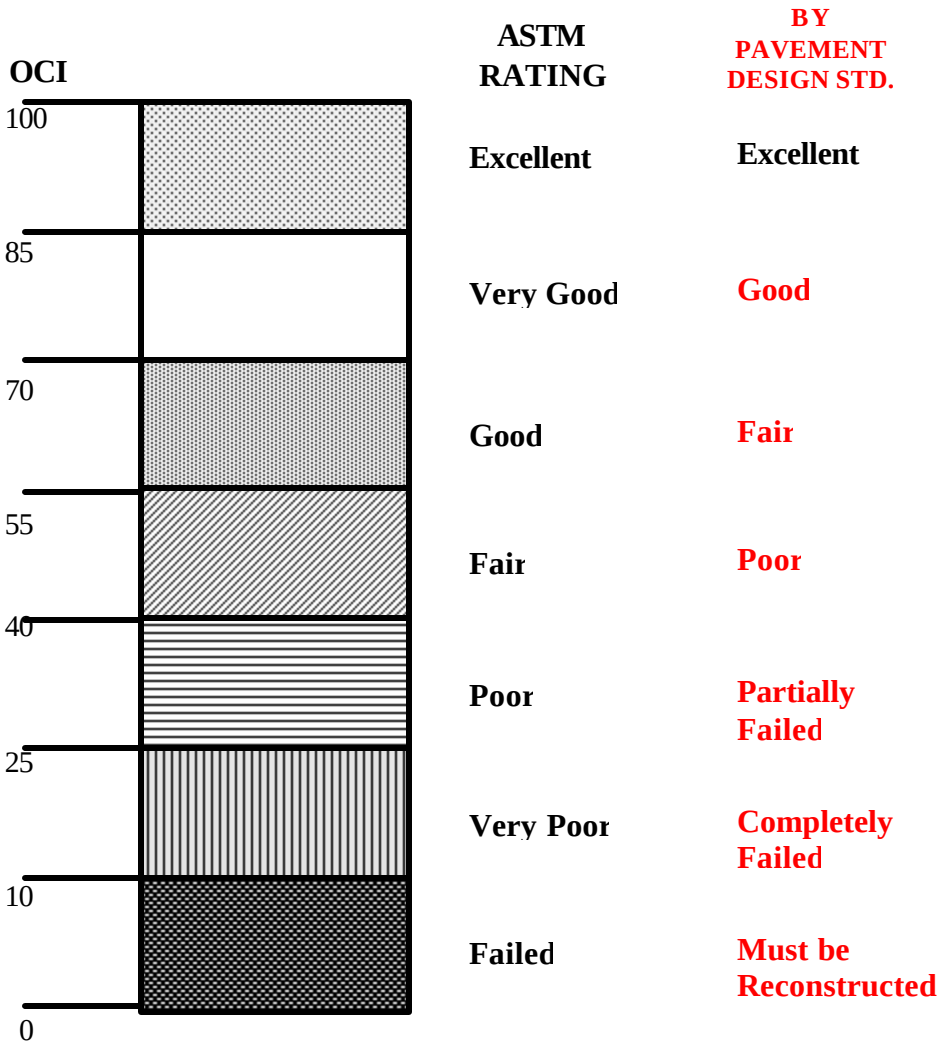


Figure 10 - OCI/PCI - Scale and Condition Rating

Note: This scale is used quite extensively in the literature and the ASTM standard. However, it is quite misleading when compared to standard excepted pavement design procedures. In this figure the scale to the farthest right side is more representative of the true nature of the actual condition of the pavement.

Multiple Distress Index Options

To allow the software to use all the above indices and the various options associated with them in a single program and to allow for understandable documentation, three separate and new index definitions are being proposed, the CDI, CDI and CSI. Further, within the software the individual distresses included within each are definable by the user. Separate indices for distress (all, structural & non-structural), ride, rutting, skid/roughness and NDT structural will also be included. These new indices along with the original are given below.

The need for more than one index in the management of an agency's pavements should be obvious from the preceding discussions. To accommodate this, the following different indices are being proposed. It may be advisable to consider others, such as a drainage index, frost index, etc. The WSDOT currently uses separate indices for distress (psc), ride and rutting.

Proposed new indices:

- **OCI** **Overall Composite/Combined Index**- This index can be defined separately for each pavement type and functional classification and can be a function of the following seven indexes. Generally this index is set equal to the CDI.
- **CDI** **Combined Distress Index** – this index is comparable to the ASTM PCI and the WSDOT "Local Agency **PCR_2**" indexes depending on how your CenterLine rating system is setup. Within the CenterLine software the CDI is in general a combination of the CSI and CNI.
- **CSI** **Combined Structural Index** – this index can be computed and used in two different ways within the software. It can be set to use the **PSC** equations or it can be computed from the standard ASTM deduct curves. This allows for full compatibility with WSDOT procedures. The user can select the individual distresses used in computing this index when using the CSI. Generally the CSI is setup to correspond to the PCR_1 by the cities and as the PSC by the counties.
- **CNI** **Combined Non-Structural Index** – This index is used to model the non-structural or environmental distresses such as raveling, reflective cracking etc. The CNI and CSI can be used in the PMS repair strategy process to make decision on MR&R actions.
- **RTI** **Rutting index –** This is a separate index, but rutting can also be included in the CDI, CNI and CSI indexes.
- **RDI** **Ride index –** The International Ride Index (IRI) can be used here. However, other considerations are possible.
- **NSI** **NDT Structural index** – This index can be defined by different variables. The two key variables that must be included are the deflection basin area and the ASHTO structural number. Continued research related to the development and use of this index is needed. This index has the potential of being the most import index for defining and managing your pavement MR&R activities. This is because what all the other indices are attempting to do is tell you when to perform MR&R operation, while the real indicator of this is the structural properties/condition of your roadway, which defines the actual structural remaining life of a given pavement. This data is provided by this index and the data required to develop it. The only reason it is not currently used by most agencies is that the data required is more expensive.
- **SKI** **Skid or roughness index –** Skid resistance and roughness are in general two different distresses or variable, the skid is an expensive measurement and requires special equipment. The use of roughness for this index is the preferred option.

Original Indices:

- **PSC** **Pavement Structural Index** – This index is included in the CenterLine PMS and can be used in place of the CSI. It can also be used to define the OCI.
- **PCR_1** **Original WSDOT method**
- **PCR_2** **Local Agency Windshield method -**
- **PCR_3** **StreetWise Condition Index** – This index is also included in CenterLine PMS.

It is recommended that the CDI be used for any state wide comparisons, while defining the final rating system in such a manner as to allow for all past indices to be compute from the same procedures or standard algorithm.

Multiple Index Definition and Control

The above indices are user definable within certain limitations and guidelines. First the distresses included in the combined distress indices, the CDI, CSI and CNI, are user definable. An example of how these are most generally setup is shown in Figure 11 below. The CSI is intended to contain the structural or fatigue related distresses, the CNI the non-fatigue related and the CDI contains all pavement surface distresses. The rutting can be included with the combined distress indices or it can be left out and used only in the separate rutting index (RTI). The rutting index is calculated automatically if data is present. This is also true for all the other not combined distress indices.

Figure 11 Combined Index setup form

The scale and range associated with how the data is collected for each of the proposed seven indices can be defined by the user. No matter how each is setup, the actual internal index is stored and maintained in a normalized form where they all vary from 0 to 100 with 100 being the best or new condition of the

variable/s being defined by the given index. This allows all indices to be compared and worked with, from within the software and related analysis and reporting operations in an easier and more consistent fashion. See Figure 12 for details on how this is done. The "Factor "column defines the OCI, which is a weighted average of the other indices. As shown here the OCI is equal to the CDI. All factors must add to 1.0, therefore, if you set the CDI factor to 0.6 and the RTI factor = 0.4, the OCI would be 60% influenced by the CDI and 40% by the RTI or rutting index. The "Worst" and "Best" columns define the upper and lower limits of the variable/s which define a given index. The "Worst" value can be greater than the "Best". The "LMY Source" ratio buttons define which curve to reference the others to when doing the curve fitting operations. All of the non-combined indices could actually be used for any user defined purpose.

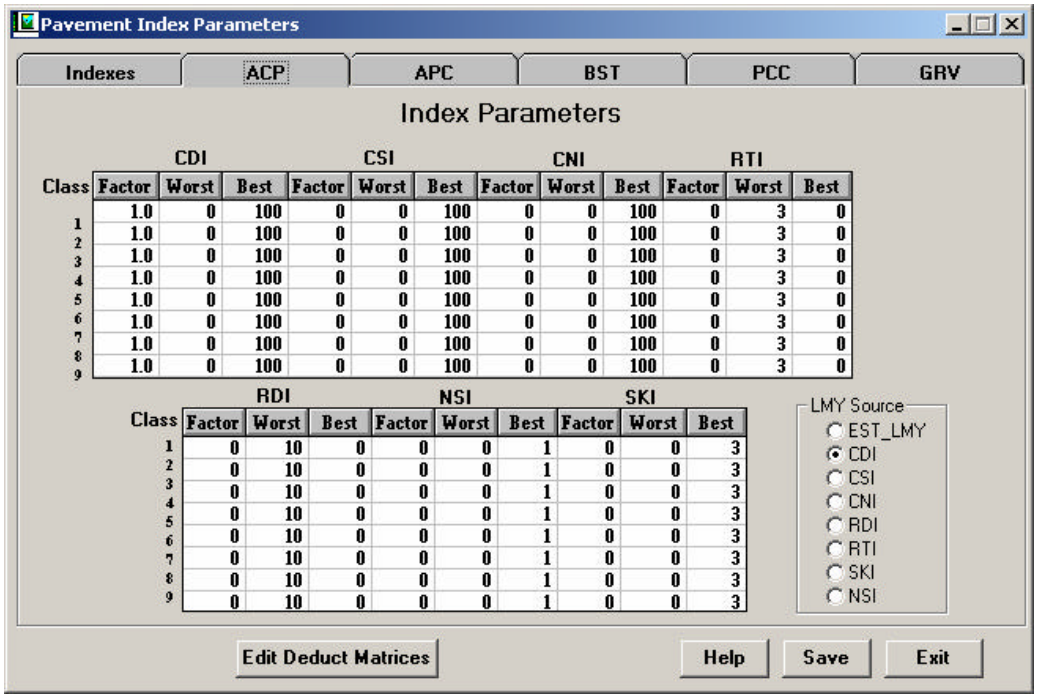


Figure 12 Multiple Index definition form

References:

1. WSDOT – WA-RD 274.1
2. NWPMA/WSDOT Raters Manual #1
3. NWPMA/WSDOT Raters Manual #2
4. ASTM standards for roads and parking lot pavements (D6433-99)
5. Pavement Maintenance Management for Roads and Parking Lots, U.S. Army Corps of Engineers, Technical Report M-294, October 1981

Appendix A

Deduct Curve Development

Recommendations for a Final Index Score Algorithm

The WSEXT method outlined in this manual is presented as a starting point for the development of a statewide recommended or standardized rating system for Washington State Local Agency use. As discussed, this system was developed by the local agencies themselves and was agreed to by WSDOT in 1993. However, further work may need to be done on developing deduct curves that better fit Washington Local Agency use. Procedures and recommendations for the development of these deduct curves and score calculations are presented here. The curves and deduct matrix values currently in use and presented in this proposed standard may be sufficient and may be used as is. However, some new curves and possible changes to existing curves are being recommended. If there are to be changes to the existing deduct curves, current score values in use by various agencies could change. This may present problems and would need to be considered or addressed.

You may want to consider separate curves for City, County, small or large agencies and Urban and/or Rural networks or sub-networks. Procedures or options should also be provided to allow each agency to modify the system to meet their needs. If a single standard index (set of curves) is defined and required to be computed for statewide use/comparisons it makes no difference or should be of no concern as to how or what other indices are in use or how they are being used.

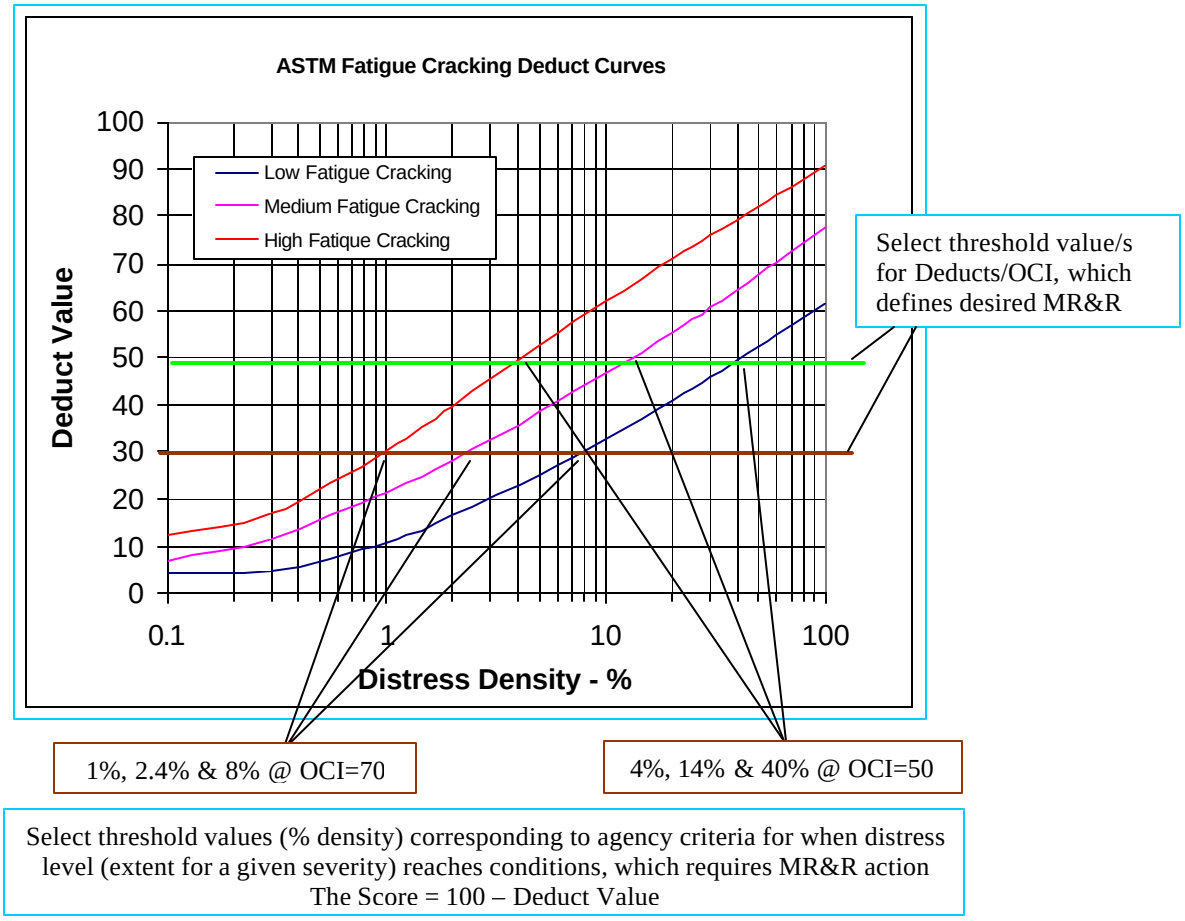


Figure A1 - Deduct trigger values for Fatigue Cracking

The above figure outlines a process for developing deduct curves and also helps to better understand the use and interpretation of these curves. The idea here is that for each distress type, one or more threshold value/s is set and corresponding density levels for the low, medium and high severity levels are established. Then the deduct curves are created by drawing lines through these points with all lines beginning at or near the zero extent and zero deduct point.

A hypothetical example for fatigue cracking might be: Set the threshold at 50 deduct points. This is where you want to define the need for rehabilitation (say an overlay) or other action. For the low severity you decide to define this point to happen at an extent of 40%, for medium severity the extent will be 14% and high severity will be 4%. See the above figure for how this looks and the Figure below. In this case we have also define a second threshold level at a deduct value of 30, for extent ranges of 8, 2.4 & 1. You may wish to define this as the threshold where you wish to apply routine or preventative maintenance. All existing deduct curves need to be looked at using this same process to see if they meet your current needs. See the Figure below which summarizes this information for the current deduct curves.

What is recommended here is to start with the ASTM curves and looks at the possibility of modifying these to better meet local use. It is also recommended that an option be provided to allow for the use of a matrix approach for collecting data on raveling and flushing (if the proposed unit conversion feature is included, this option would also be included). This is based on two arguments. First, there is not much you can do but apply a seal coat, overlay or reconstruct a roadway to address these defects. Therefore, detailed area type measurements do not fit the desired rehabilitation and are not necessary. Also, raveling is an extremely difficult distress to observe and measure accurately and consistently. It is by far the hardest distress to train raters to quantify in a consistent and repeatable manner.

The following is a Figure, which could be used as a starting point for the development of new deduct curves. It also provides a clear documentation of the existing WSEXT/AXTM deduct curves. The recommended score calculation procedures/algorithm should follow the ASTM standards for roads and parking lot pavements (D6433-99) even though the curves are to be modified. It should be noted that 100% or at least full single lane sampling should be used and not the 10% sampling allowed for in this standard.

An expanded blank version of the following Figure is provided for the committee member (and to all agencies), which is to be filled out and a statistical analysis should be made of the results to come up with a final recommendation for new deduct curves. This Figure summarizes the procedure outlined in the previous figure for each distress type and severity. Just ask your self, given the "Deduct Trigger Points" at what distress density (extent) would I (or do I currently) perform a given MR&R action to repair or preserve this pavement. Detailed discussion and interactive interaction on filling out this table should be performed at our next committee meeting and deduct curves should be developed from this interaction and test analysis should be done to evaluate the results of both the agreed to curves and the extreme upper and lower limits discussed by the group. I would be willing to do this analysis or at least assist in the performance and evaluation of the analysis and results. The Q-Curve correction procedure would also have to be evaluated as to its effect on changes in current deduct curves.

#	Flexible Distresses	Deduct Threshold Pts*	% Extent value for Each Severity Level @ Deduct Trigger Pts			Extent Limits		Deduct Source	Comments
			Low	Med	High	Low Limit	High Limit		
1	Rutting/Waves ^	100	50	66	90	0.1	100	ASTM #15	Assume 100% extent
		-	25	45	60			WSDOT	PCR_2
2	Alligator/Fatigue Cracking	50	40	14	4	0.1	100	ASTM #1	
		30	8	2.4	1			"	
3	Longitudinal Fatigue Crks ^	30	8	8	8	0.1	100	ASTM #1 low	Convert to area & add to low AC
4	Longitudinal Non-Fatigue	30	30	9.5	2.4	0.2	30	ASTM #10	
5	Transverse Cracking	30	30	9.5	2.4	0.2	30	ASTM #10	
6	Raveling	-	-	-	-	-	-	WSDOT	Use PCR_2 matrix approach
7	Flushing	-	-	-	-	-	-	WSDOT	Use PCR_2 matrix approach
8	Maintenance Patching	30	40	9	3	0.1	50	ASTM #11	
9	Utility Patching ^	-	-	-	-	-	-	No deducts	Measure distress only
10	Corrugation & Waves	30	40	4.5	0.6	0.1	100	ASTM #5	
11	Sags & Humps	30	6.4	1.6	0.21	0.1	10	ASTM #4	
12	Block Cracking	20	15	40	5	0.1	100	ASTM #3	
13	Edge Condition	10	9	1.4	0.3	0.1	20	ASTM #7	
14	Crack Sealing	-	-	-	-	-	-	N/A	Inventory item only
15	Ride Quality	30	-	-	-	-	-	N/A	0-5 subjective guess?
16	Drainage	30	-	-	-	-	-	N/A	Open or closed, good or bad?

- * Values given here for trigger and % extent are taken from the ASTM curves
- ^ Does not have unique deduct curves – new curve may be needed or desired

Note: Rigid or PCC pavements should stay as specified in Figure 7 or the ASTM system could be used directly.

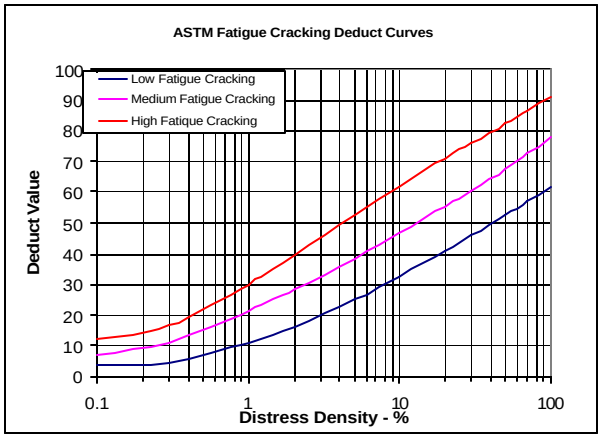
Figure A2 - Deduct trigger values and deduct severity points for all distresses

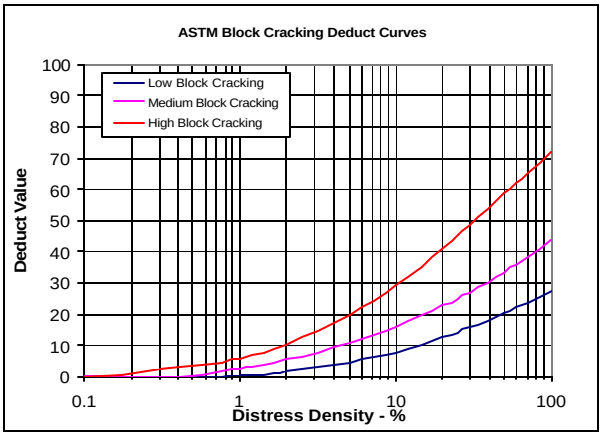
#	Flexible Distresses	Deduct Threshold Pts*	% Extent value for Each Severity Level @ Deduct Trigger Pts			Extent Limits		Deduct Source	Actions
			Low	Med	High	Low Limit	High Limit		
1	Rutting/Waves ^	100	50	66	90	0.1	100	15	
		-	25	45	60			W	
2	Alligator/Fatigue Cracking	50	40	14	4	0.1	100	1	
		30	8	2.4	1			"	
3	Longitudinal Fatigue Crks ^	30	8	8	8	0.1	100	1-Low	
4	Longitudinal Non-Fatigue	30	30	9.5	2.4	0.2	30	10	
5	Transverse Cracking	30	30	9.5	2.4	0.2	30	10	
6	Raveling	40	-	80	10	0.1	100	W	
		16	1	7.5	80				
7	Flushing	40	-	100	27	0.1	100	W	
		20	100	24	8				
8	Maintenance Patching	30	40	9	3	0.1	50	11	
9	Utility Patching ^	-	-	-	-	-	-	?	
10	Corrugation & Waves	30	40	4.5	0.6	0.1	100	5	
11	Sags & Humps	30	6.4	1.6	0.21	0.1	10	4	
12	Block Cracking	20	15	40	5	0.1	100	3	
13	Edge Condition	10	9	1.4	0.3	0.1	20	7	
14	Crack Sealing	-	-	-	-	-	-	N/A	
15	Ride Quality	30	-	-	-	-	-	N/A	
16	Drainage	30	-	-	-	-	-	N/A	

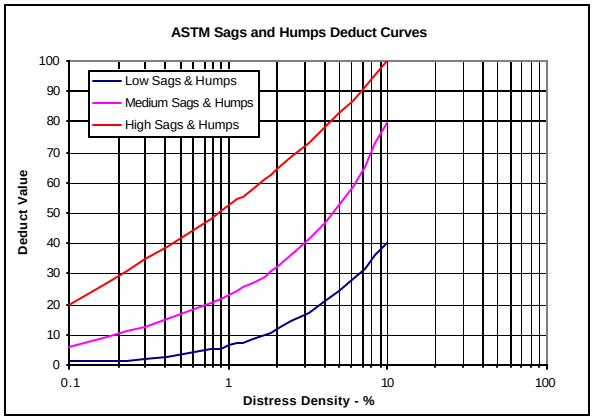
#	Flexible Distresses	Deduct Threshold Pts*	% Extent value for Each Severity Level @ Deduct Trigger Pts			Extent Limits		MR&R Type	Your Actions
			Low	Med	High	Low Limit	High Limit		
1	Rutting/Waves ^							Reconstruct	
								Overlay	
								Maintenance	
2	Alligator/Fatigue Cracking							Reconstruct	
								Overlay	
								Maintenance	
3	Longitudinal Fatigue Crks ^							Reconstruct	
								Overlay	
								Maintenance	
4	Longitudinal Non-Fatigue							Reconstruct	
								Overlay	
								Maintenance	
5	Transverse Cracking							Reconstruct	
								Overlay	
								Maintenance	
6	Raveling							Reconstruct	
								Overlay	
								Maintenance	
7	Flushing							Reconstruct	
								Overlay	
								Maintenance	
8	Maintenance Patching							Reconstruct	
								Overlay	
								Maintenance	
9	Utility Patching ^							Reconstruct	
								Overlay	
								Maintenance	
10	Corrugation & Waves							Reconstruct	
								Overlay	
								Maintenance	
11	Sags & Humps							Reconstruct	
								Overlay	
								Maintenance	
12	Block Cracking							Reconstruct	
								Overlay	
								Maintenance	
13	Edge Condition							Reconstruct	
								Overlay	
								Maintenance	
14	Crack Sealing							Reconstruct	
								Overlay	
								Maintenance	
15	Ride Quality							Reconstruct	
								Overlay	
								Maintenance	
16	Drainage							Reconstruct	
								Overlay	
								Maintenance	

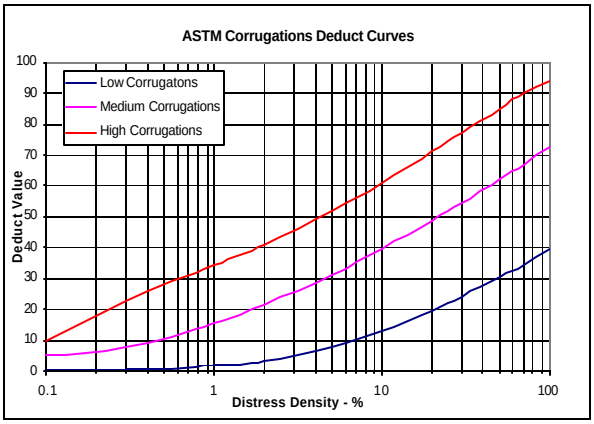
Figure A3 - Blank form for setting new trigger points and corresponding severity level points

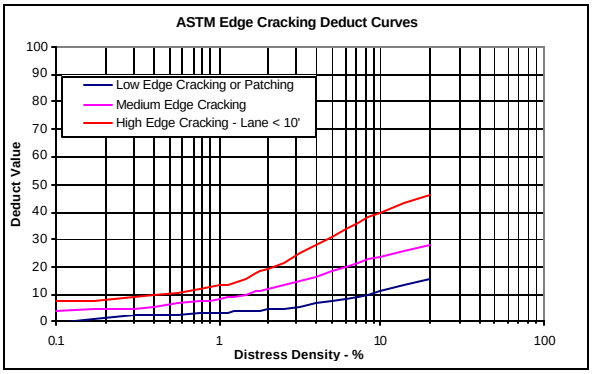
Figure A4 - ASTM/PAVER Deduct curves and WSDOT matrix values used the WSEXT algorithm

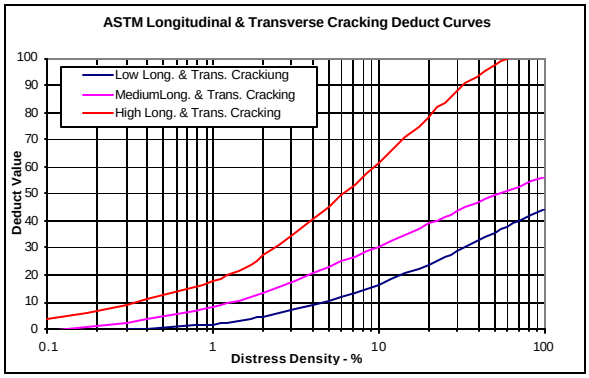






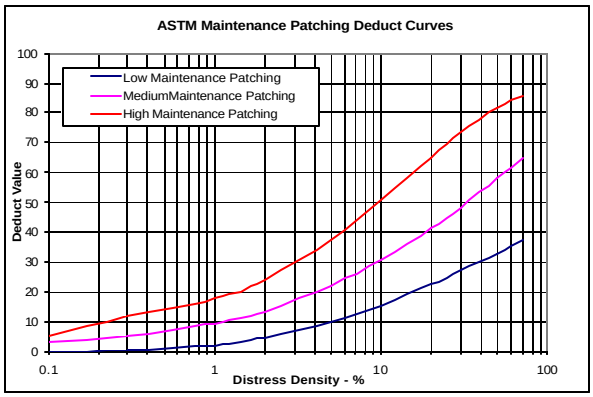


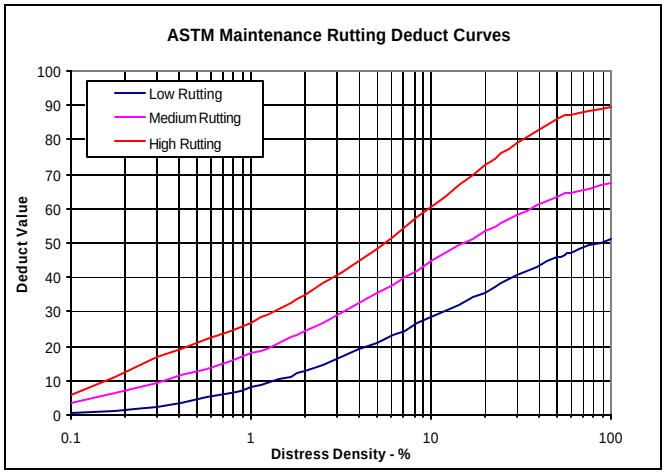


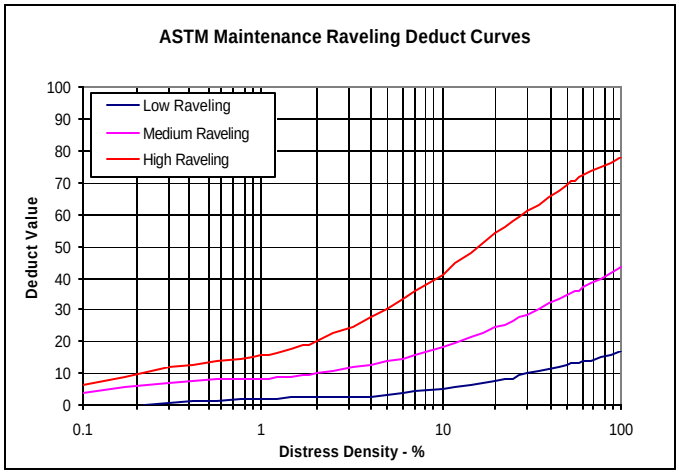


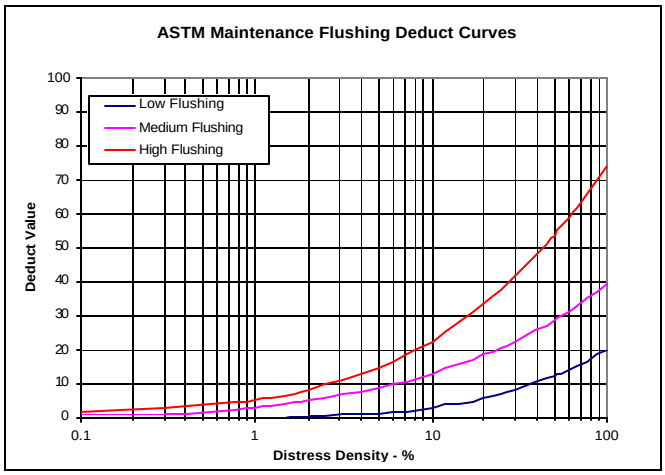
Extent Range	Raveling			Flushing		
	Low	Med	High	Low	Med	High
1	5	20	45	5	20	45
2	10	30	65	10	30	65
3	15	40	75	15	40	75

Extent Range	Rutting		
	Low	Med	High
100%	25	45	60









Need to add PCC deduct curves and the q-curves and the corresponding equation parameters used for generating them.